

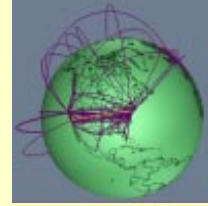


From National Information Infrastructure To Global Collaboration Infrastructure



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Information Technology Laboratory
National Institute of Standards & Technology

KTIS'96 - November 1996

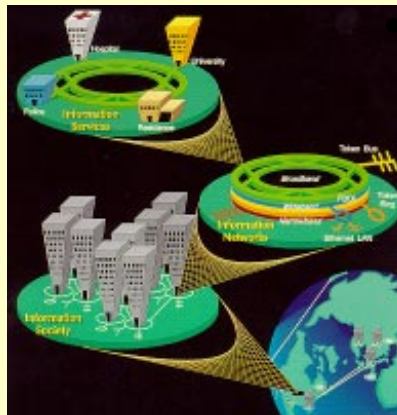
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GCI



Megatropolis Vs. Infopolis

Many disjoint
network
technologies will
be deployed, each
dedicated to a
particular
networking
objective and each
providing its own
set of restricted
services



Competencies and
interests of the
academic and
commercial
communities may
come together and
drive a concerted
effort to create a
network that can be
the basis for
commerce, education,
and research

Picture Source: Future Telecommunications Information Applications,
Services, & Infrastructure - Robert K. Heldman

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Visions of the Future?

- a 500-channel interactive multimedia video/cable network; numerous "edutainment" multimedia products and services; telephone systems supporting voice, data, image, and video;
- an electronic marketplace for commercial and/or consumer products and services;
- a public network for government information and services, medical information, and education; or
- a source for discovering innovative applications for information technology in research, education, and commerce.



Presentation Content

- **Status of the NII**
- **Key Technologies**
- **Challenges**
- **The vision**

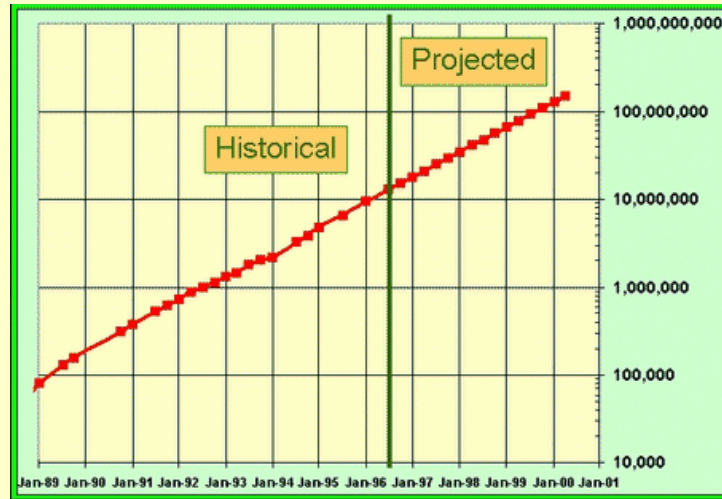
STATUS OF THE NII



Internet Hosts 1989-96



Internet Hosts - Overall Trend

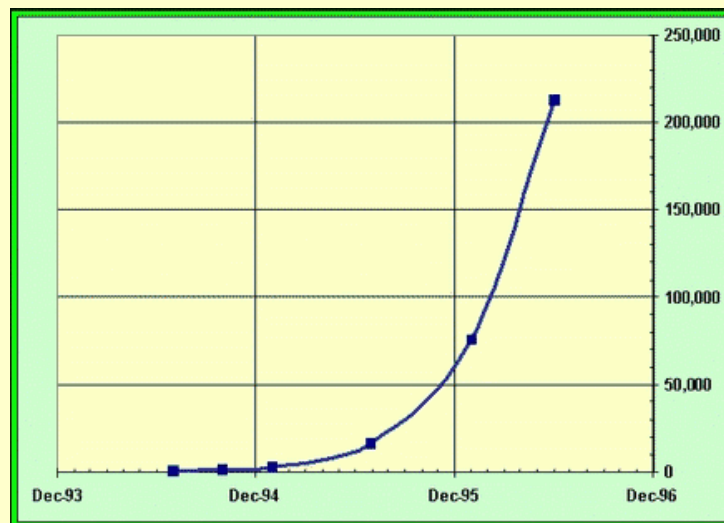


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Source: networks Wizards (www.nw.com) - Picture: A.M. Rutkowski - General Magic Inc. August 1996

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WWW - Prefixed Hosts

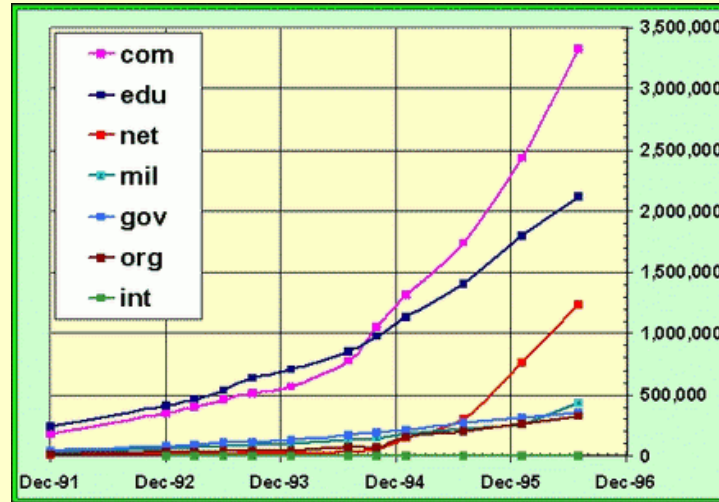


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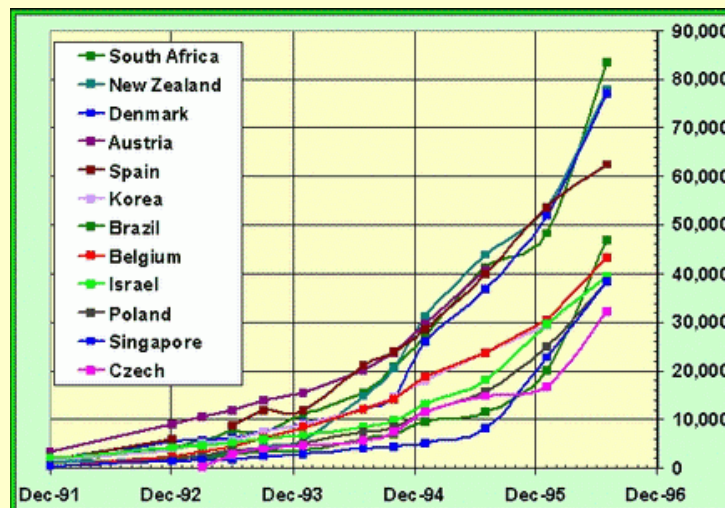
Source: networks Wizards (www.nw.com) - Picture: A.M. Rutkowski - General Magic Inc. August 1996

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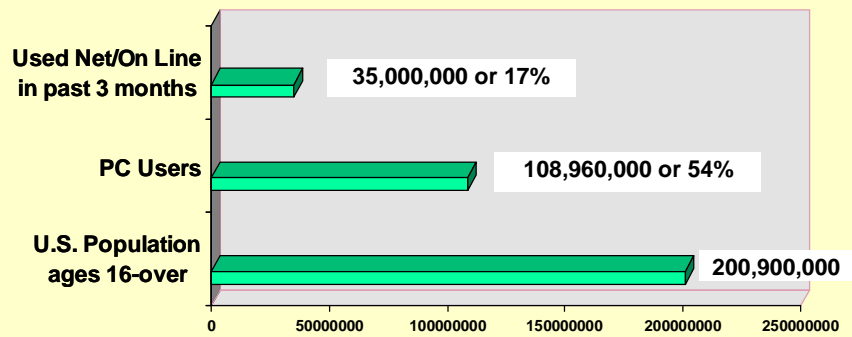
Hosts: Three Letter Domains



Hosts: Three letter domains

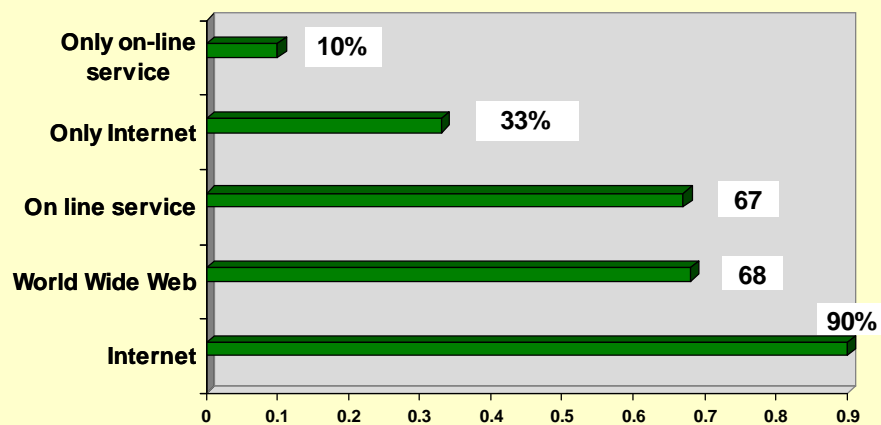


How many people are on-line?



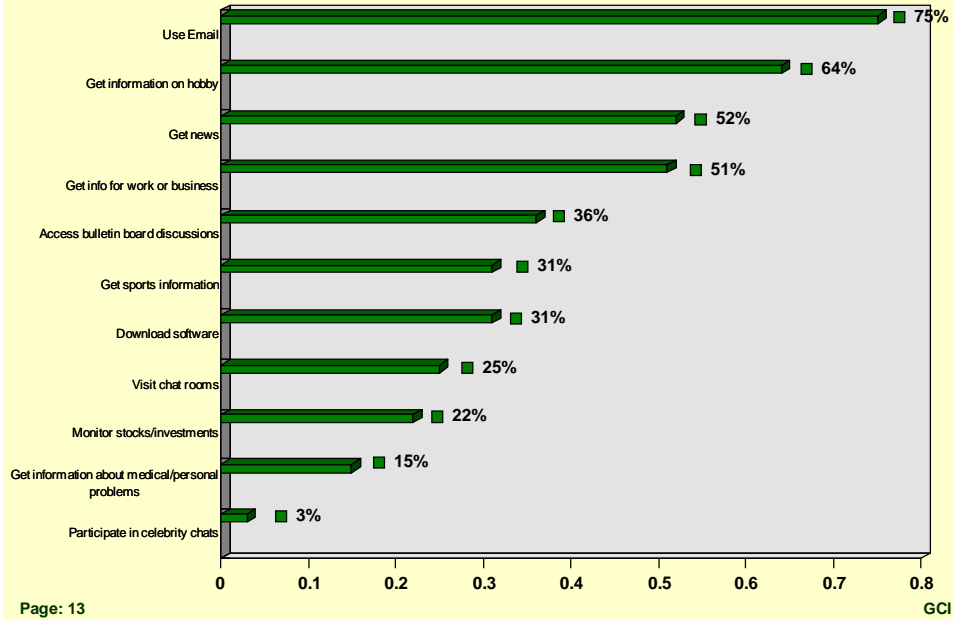
USA Today October 9, 1996 - sources: IntelliQuest, Yankelovich, Georgia

Of the 35 millions adults, % who use:



USA Today October 9, 1996 - sources: IntelliQuest, Yankelovich, Georgia Institute of Technology

On line activities



KEY TECHNOLOGIES

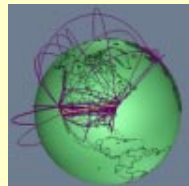
NETWORKING
HUMAN-COMPUTER INTERACTION
ARTIFICIAL INTELLIGENCE
VIRTUAL LIBRARIES

NETWORKING

- ✓ E-Mail - Basic NII Service
- ✓ Multicasting and MBONE
- ✓ High Performance Networks

Electronic Mail

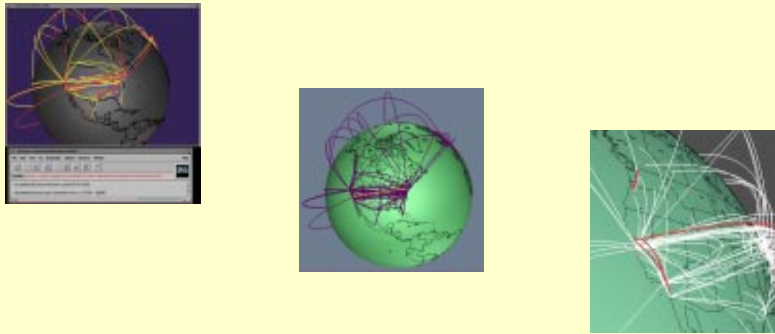
**A key indicator of the penetration of
computer technology**



**An asynchronous, electronic,
interchange of information, supported
with mechanisms allowing the creation,
distribution, consumption, processing,
and storage of messages.**

**While the technology started with the
exchange of simple text messages, it is
evolving into a powerful means of
transmitting and viewing multimedia
messages containing high-resolution
color pictures, movie clips, and sound.**

Multicasting and MBone

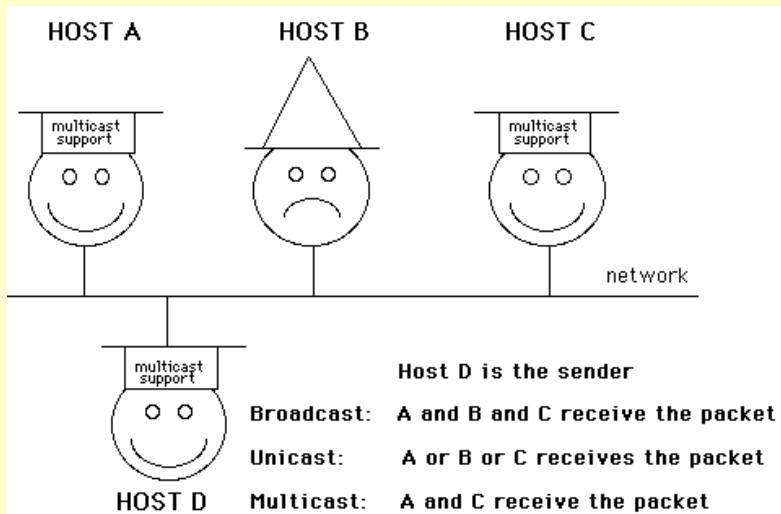


What is Multicasting?

Multicasting is a technical term that means that you can send a piece of data (a packet) to multiple sites at the same time.

Multicast may be viewed as the Internet version of selective broadcasting in a very similar way to a television viewer selecting what is viewed by millions of other people. Multicast enables users to broadcast packets of information to anyone who is listening and has the right type of equipment and software.

Different reception types



What is Mbone?

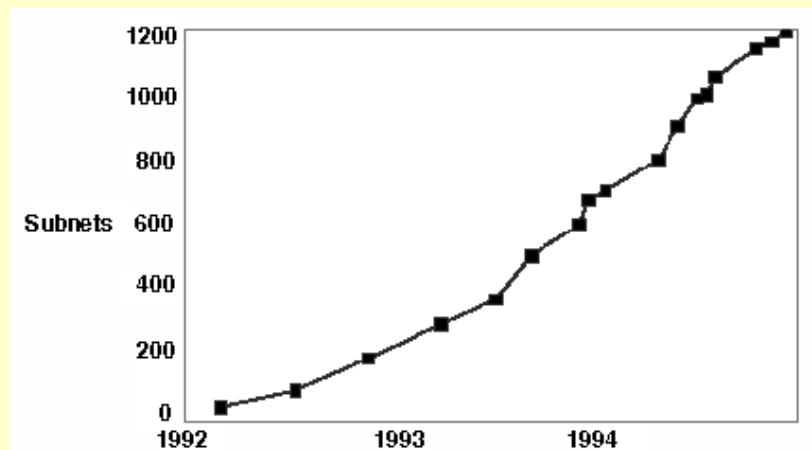
The MBONE is an outgrowth of the first two IETF "audiocast" experiments in which live audio and video were multicast from the IETF meeting site to destinations around the world. The idea is to construct a semi-permanent IP multicast testbed to carry the IETF transmissions and support continued experimentation between meetings. This is a cooperative, volunteer effort.

The MBONE is a virtual network. It is layered on top of portions of the physical Internet to support routing of IP multicast packets since that function has not yet been integrated into many production routers. The network is composed of islands that can directly support IP multicast, such as multicast LANs like Ethernet, linked by virtual point-to-point links called "tunnels".

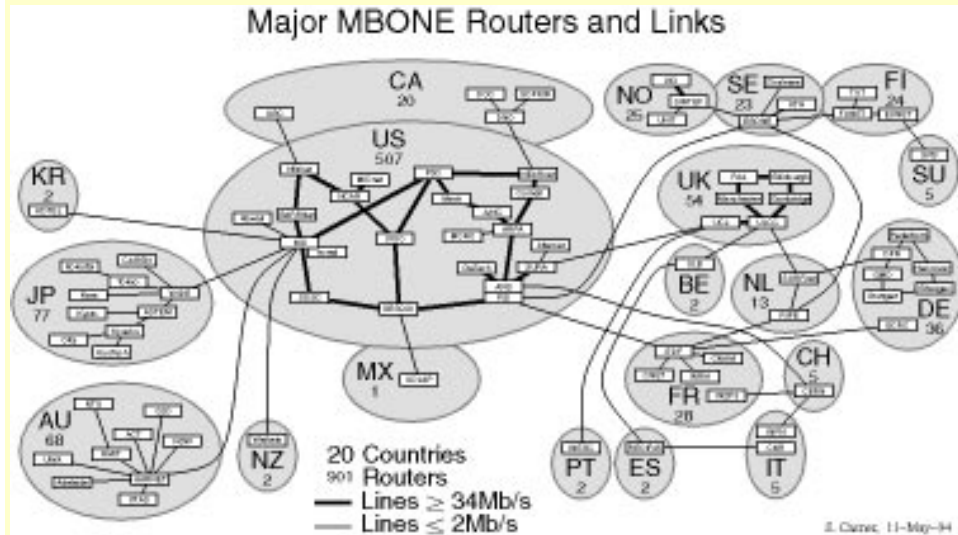
MBone - History

- The first multicast tunnel was established between BBN and Stanford University in the summer of 1988.
- The IP Multicast Protocol (RFC 1112) was adopted by the Internet Engineering Task Force (IETF) in March of 1992 as the current, standard protocol for building multicast applications on the Internet.
- Today, about 1,700 networks (in about 20 countries) are on the MBONE, making the MBONE approximately the size that the entire Internet was in 1990.

Growth of the MBone

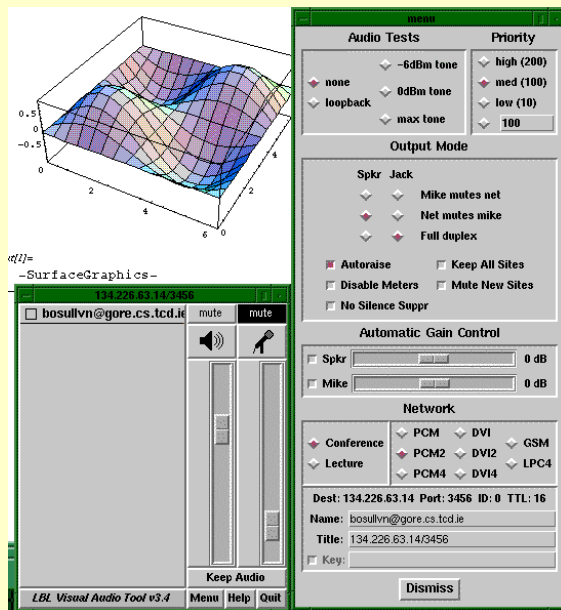


Topology of the MBone



One Vision: GII and Multicasting

The MBONE will make the Internet a hotbed of real-time multimedia communications. In essence, it will become a brand of interactive boardroom, classroom, television, cinema, video game, and edutainment of the kind only dreamed of in the hype about the information superhighway





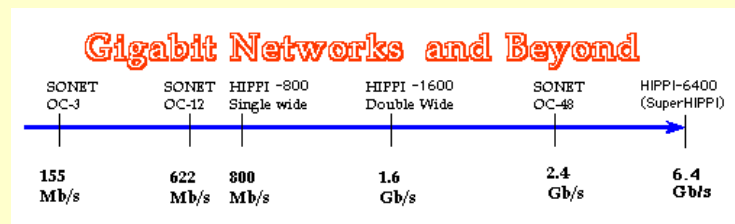
Mbone - Vision (Continued)

- ✓ Watch a customized version of CNN from your computer's desktop
- ✓ Engage 5,000 other people in a huge intercontinental computer game
- ✓ See reruns of "Gilligan's Island" and share your snide comments in real time with faraway friends
- ✓ Put your own garage band's rehearsals online for all to see (and hear)
- ✓ Automatically download and install authorized upgrades and bug-fixes to your computer software, without your intervention
- ✓ "Chat" in real time with 20 other users (as you can with Internet Relay Chat, except that you'll use your voice instead of your overworked fingers)

Page: 27 Source: *MBONE: Multicasting Tomorrow's Internet* - by Kevin Savetz, Neil Randall, and Yves Lepage GCI



High Performance Networks



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Asynchronous Transfer Mode

Emerging as the primary network technology for next-generation, multimedia communication

- ▲ **Born from standardization efforts for Broadband Integrated Services Digital Network, (B-ISDN) which began in the CCITT in the mid 1980s.**
- ▲ **Provides a specific connection-oriented packet switching transfer mode based on fixed length cells (i.e., 53 bytes - 5 bytes for header and 48 bytes for information).**
- ▲ **ATM cells flow transparently through the network, such that no error control processing protects the information field of ATM cells inside the network.**

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DARPA testbeds

- ✓ **In 1990 NSF and DARPA formed the Gigabit Testbed Project and MAGIC.**
- ✓ **In 1994 DARPA created a metropolitan area network, called ATDNet, circling Washington, D.C.**
- ✓ **During 1994, in cooperation with the HPCMod program, DARPA created the ACTS/ATM Internetwork (AAI) linking approximately nine sites across the United States utilizing ATM at 45 Mbps rates and moving to 155 Mbps.**
- ✓ **In cooperation with NASA, DARPA and NASA have sponsored the ACTS High Data Rate (HDR) terminals.**

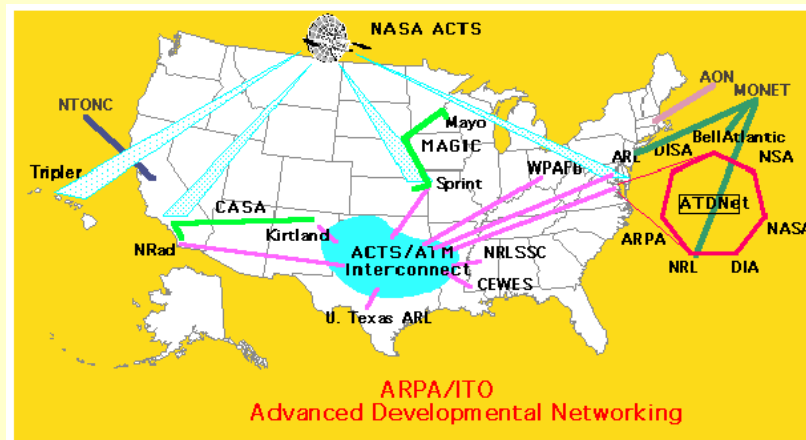
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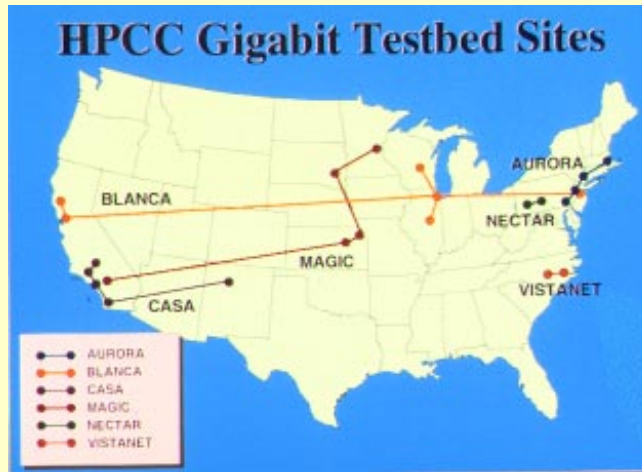
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DARPA Testbeds (continued)

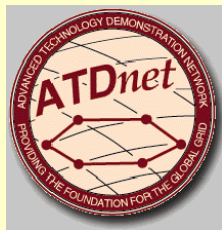
- ✓ DARPA is also investing in future networking technology by exploring extremely high bandwidth (30+ Gbps) optical transmission at the University of California at Santa Barbara.
- ✓ The BIT program sponsors the MONET project in New Jersey, the NONTC projects in the San Francisco, California region, and the WEST project in Southern California. These projects represent the very leading edge in network technologies.
- ✓ Besides the very high bandwidth technology projects, DARPA continues to invest in mobile and untethered technologies through its Global Mobile program and experimental protocols on DARTNet.

DARPA Testbeds

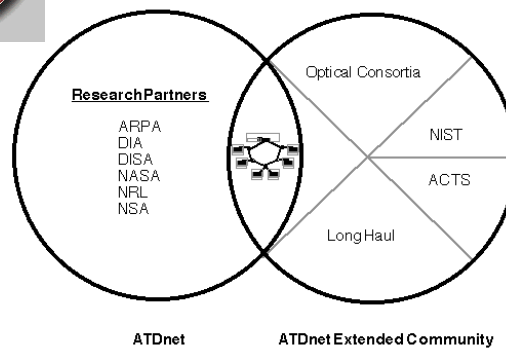


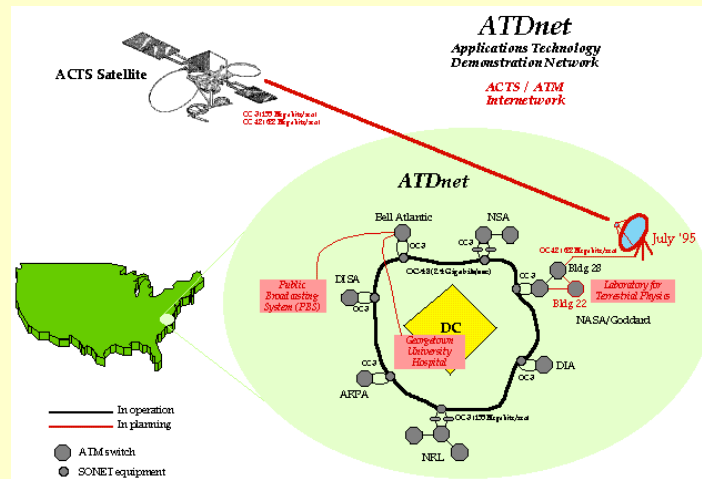


Advanced Technology Demonstration Network



The ATDnet Initiative





ATDNet - Objectives

- ✓ Acquire early experience with advanced communications and network technologies, primarily ATM and SONET, but also including direct fiber access
- ✓ Help industry and Government assess and better understand characteristics of a suitable technology base and the needs of NII-scale public networks
- ✓ Establish an adaptable, extensible environment for evaluating developmental and commercial products and services in realistic, user-stressing deployments
- ✓ Experiment with operation, maintenance, and management of these technologies and services as the testbed is expanded to include multiple vendors, multiple technologies, and links to other networks and commercial service providers
- ✓ Deploy and assess a diversity of information security approaches
- ✓ Enable and evaluate innovative applications, particularly those requiring 100 Megabit/sec to 1 Gigabit/sec to the end user
- ✓ Feed results back into planning, engineering, and development efforts directed toward next-generation product and service offerings
- ✓ Support technology transition to DoD and the broader Federal High Performance Computing and Communications (HPCC) program



Selected Accomplishments of the Gigabit Testbed Projects

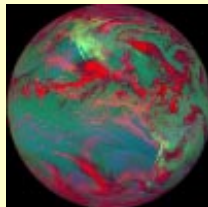
- ✓ Operation of high speed data transmission systems not previously achieved in long distance networks (2.4 billion bits per second across thousands of kilometers).
- ✓ New very high-speed transport protocols for wide-area networks (new transmission records of 500-800 Mb/s between hosts over long distances)
- ✓ New ATM switches to route data at higher speed across the testbeds (pushed switching to 155 Mb/s, 622 Mb/s, and faster).

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HUMAN-COMPUTER INTERACTION



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"If the interface is ineffective, the system's functionality and usefulness are limited; users become confused, frustrated, and annoyed; developers lose credibility; and the organization is saddled with high support costs and low productivity."

Human-Computer Interaction (HCI) is the study of how people design, implement, and use interactive computer systems, and how computers affect individuals, organizations, and society.

Why is it so complicated?

- **misunderstanding of the user needs and of the tasks to be performed**
- **misunderstanding of human cognitive abilities**
- **lack of guidelines and metrics to guide the development of advanced user interfaces.**

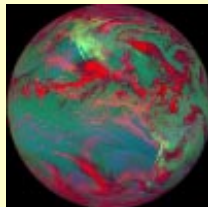


Major elements of HCI research

- **New interaction paradigms** that enable users to communicate with computers and with others using computers in more effective, human ways;
- **Fundamental understanding** of the nature of interaction that will enable users to achieve their goals more directly, including a better understanding of the limitations of human information processing; and
- **Engineering methods** for interactive system design and development that will improve the quality and reduce the costs of user interfaces for new systems.



ARTIFICIAL INTELLIGENCE





Artificial Intelligence

Bringing dispersed library resources and entertainment materials to the ordinary citizen leads to wasted time and effort searching for the appropriate sources of information.

As the information is dispersed over several sources, the user must go through the process of accessing several information sources, learning their different user interfaces and query languages, and, later, undertaking the cumbersome task of information integration.

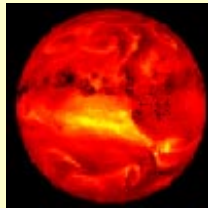


A Role for AI in the NII

To provide tools and technologies to navigate a labyrinth of databases and services

- **goal-oriented, cooperative, and customizable human-computer interfaces** that handle different modalities (e.g., natural language, gesture, graphics, or animation), operate as intelligent systems that interpret the requests from the users and perform the required tasks, and adjust themselves automatically to specific users
- **intelligent indexing, access, and retrieval** of all forms of information

DIGITAL LIBRARIES



Changing role of the libraries

Traditional library

- carefully selected, acquired, and cataloged collections of items stored within the facilities of the “classical” library are only available to the individuals that physically enter the library building

Library of the NII

- a source of inexpensive and extensive electronic collections of digital information -- including text, pictures, audio, and video -- accessible remotely and simultaneously to readers located at multiple sites



Digital Libraries in the NII

**to effectively mass-manipulate the
information on the Internet**

**enabling technology and
infrastructure for wide-area
information management, exchange,
and collaboration**



Major Research

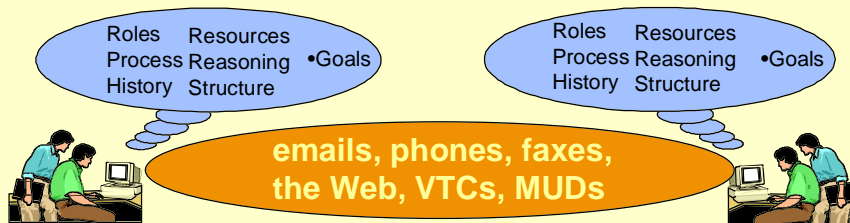
Key components/technologies

**interconnected and interoperable networks,
decentralized data and processing, databases,
navigation and retrieval tools, document delivery,
presentation standards and techniques, mass
storage, and human resources.**

**In 1994 the NSF, DARPA, and NASA jointly funded a
four-year digital libraries research and technology
development activity (See Paper Table 4)**

THE CHALLENGES

Current State of Collaboration Technology



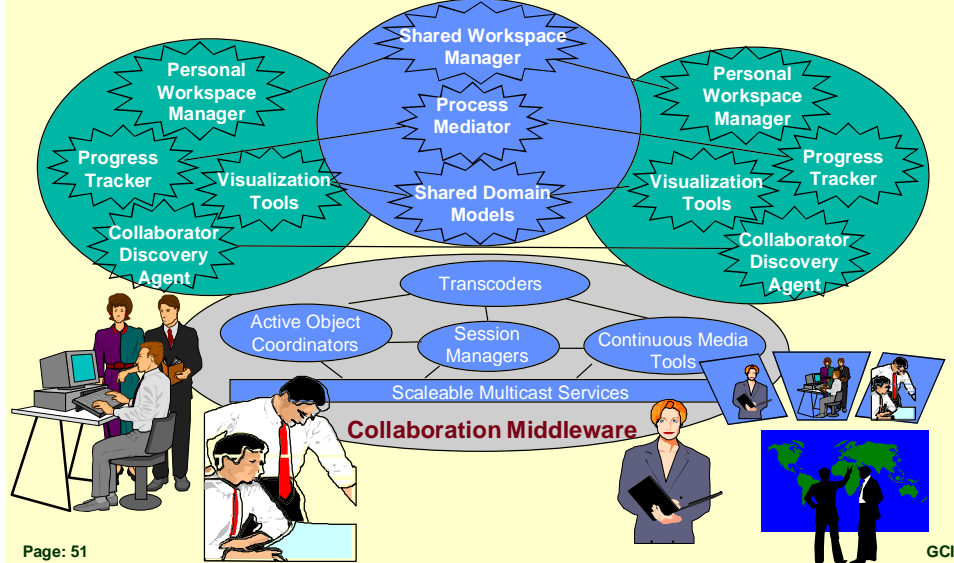
Current State of the ART...

- Videoteleconferencing supporting a few coding standards
- Multicast Backbone and related tools for video, audio, and shared whiteboard with poor synchronization qualities and limited support for interaction
- Multi-User Domains (MUDs) with text-based and 3-D graphical interfaces
- Shared X Applications
- Commercial Groupware and a growing number of Web-based Collaboration Tools
- Special-purpose Shared Applications

Limitations

- Does not scale in several dimensions
- Little interoperability among heterogeneous collaboration systems
- Weak support for asynchronous collaboration
- No support for context-based discovery of relevant collaborators and information
- Rigid (if any) process support
- Collaborators get lost in a morass of irregular data

Tools for Sharing Meaning and Views



Key Research Challenges

- Collaboration Middleware
 - #1 Scalable, Reliable Multicast Services
 - #2 Composable and Interoperable Architectures
 - #3 Resource Management
- Sharing Meaning
 - #4 Incremental Semantic Models
 - #5 Semantic Indexing of Timed Events and Multimedia Streams
 - #6 Semantic Models for Representing Goals, Objectives, and Tasks
 - #7 Group-Evolvable Processes
 - #8 Semantic Interoperability
- Sharing Views
 - #9 Control Protocols for Distributed View Sharing
 - #10 Visualizing Abstract Information Spaces
- #11 Evaluate Metrics and Methodologies



Collaboration Middleware Research Challenges

- **Challenge #1 Scalable, Reliable Multicast Services** that enable data to be sent efficiently to all end points in a session for loss-intolerant data streams, such as whiteboard transactions and distributed animation events.
- **Challenge #2 Composable and Interoperable Architectures** that enable stand-alone applications to be made collaborative with little effort and that enable different implementations of similar collaborative applications to operate effectively together.



Collaboration Middleware Research Challenges (Continued)

- **Challenge #3 Resource Management**
 - local session management algorithms to arbitrate access to non-shareable devices, to allocate resources among modalities (such as voice, video, and text) based on a user's varying task focus, and to synchronize timing among related but separate data streams
 - global session management algorithms to allocate adaptively distributed bandwidth and computation among competing demands within a session, to manage distributed floor control, to regulate distributed access to shared conference resources (such as video cameras and microphones within conference rooms), to identify the need for translating encodings (transcoders) among various formats and control protocols, to arrange for the generation of appropriate transcoders, and to map transcoders to system resources based on requirements for performance, function, and security



Shared Meaning Research Challenges

- **Challenge #4 Incremental Semantic Models** - Tools and techniques are needed to support the evolutionary development of semantic models that permit incompleteness, inconsistency, and ambiguity, that enable collaborators to merge separately developed semantic models into shared models, and that enable collaborators to increase the completeness, consistency, and precision of shared models as new information is discovered and agreed.
- **Challenge #5 Semantic Indexing of Timed Events and Multimedia Streams** to enable absent collaborators to understand quickly the current, significant state of a collaboration upon their return and to enable interested users to ask semantically significant questions about a meeting that they did not attend.



Shared Meaning Research Challenges

(continued)

- **Challenge #6 Semantic Models** for Representing Goals, Objectives, and Tasks so that computer systems can represent the semantic context of a user's activities and can relate a user's actions and information to that semantic context in order to enable intelligent software agents to provide value-added assistance, such as helping users to find potential relevant collaborators and information in real-time in the context of specific tasks.
- **Challenge #7 Group-Evolvable Processes** - Methods for groups to gracefully define and evolve process constraints in response to realistic collaboration needs. Perhaps, systems, containing knowledge about effective processes for particular tasks, team types, and group sizes, that can suggest process constraints based upon monitoring of a team's interactions and progress.
- **Challenge #8 Semantic Interoperability** - Methods to bridge differences in terminology across domains of discourse and to bridge differences in natural languages. Key challenge added by collaboration is to use spoken language and to provide the necessary translations in real-time.



Shared Viewing Research Challenges

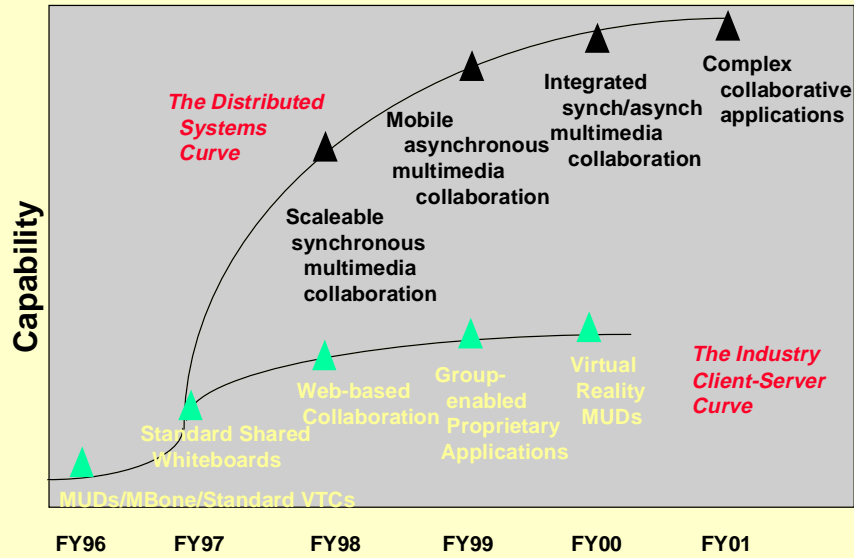
- **Challenge #9 Control Protocols for Distributed View Sharing** that allow each member within a group to take a particular, role-defined, logical view of the information space, that allow group members to see a visual effect from the viewpoint of a specific group member, that enable changes in one member's view to be reflected logically in the views of other members, and that control general access to a shared viewing space.
- **Challenge #10 Visualizing Abstract Spaces** - Techniques to visualize and navigate abstract (n-dimensional) spaces, such as executing distributed software systems and partially executed plans; approaches to map abstract information spaces onto familiar 3-D and 4-D views; methods to augment real-world views with abstract information so that, for example, soldiers can look at an approaching aircraft and see speed, altitude, heading, aircraft type, and projected flight path.



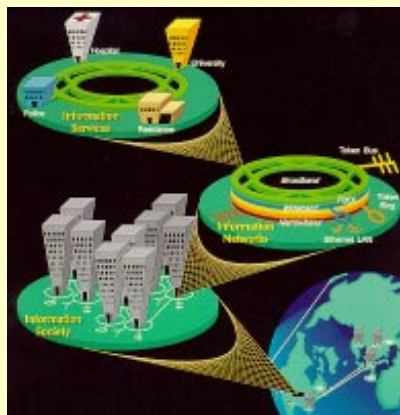
Evaluation Research Challenges

- **Challenge #11 Measurement - metrics to assess**
 - 1) the efficiency and sufficiency of underlying technology connecting users and information together,
 - 2) the effectiveness of various human-system interaction techniques, and
 - 3) the productivity effects from using a collaboration system to accomplish tasks; methods to instrument systems, to enable automated, repeatable experiments; approaches to generating significant system loads in a laboratory setting.

The Challenges



VISION





Infopolis

- ◆ In the morning, Ingmar flip on her computer and instantly complete her morning commute to a virtual meeting room where she consults with fellow members of a team designing a new electronic shopping mall.
- ◆ At noon, Ingmar switches virtually to a conference with her daughter's teachers who themselves are actually spreadout across the globe.
- ◆ Before joining her daughter to inspect progress on several school assignments arrayed across the computers comprising her daughter's virtual classroom, Ingmar "drops by" the design team meeting room to see if anyone is still working and to check on progress since her earlier visit that morning.
- ◆ Later in the afternoon, she "makes" a virtual visit to her mother on the West coast, chats a bit, "pulls" the family's last vacation video-clip from her video bank account and shares it with her.
- ◆ During dinner, the family discusses their plan to visit Ingmar's sister abroad. While her husband switches the television to the Travel Services Network, Ingmar establishes a virtual call to her sister, and starts discussing the most convenient dates while her husband orally requests information about the best itinerary, and reserves a hotel and transportation.
- ◆ After dinner, Ingmar visits her virtual bookclub where several members present some ideas for books to read over the next few months.

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GCI



Serve All people

- ➔ **Everybody should have affordable access to an essential subset of GCI capabilities. The GCI will enable a new plateau of service capabilities. While not all users will want or need all these capabilities, the GCI should support the expansion of these capabilities over time. The prices charged for accessing services will probably vary. Certain services might, like today's US 800 telephone service, be offered at little or no charge to the end user; more specialized business applications might be priced relatively higher.**
- ➔ **The GCI must be easy to use, with intuitive and consistent interfaces. The GCI will provide a variety of capabilities supporting diverse user communities. Its internal complexities should be hidden from most users.**

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GCI



Principles of Free Enterprise

- ➔ **The GCI must be structured to promote open and fair competition among information, technology, and service providers.**
- ➔ **The GCI must be designed to encourage entrepreneurship and private ownership.**



Protect the Rights of Users and Stakeholders

- ➔ **The intellectual property rights of the owners of GCI materials (information) must be protected, and incentives for creating new materials maintained.**
- ➔ **The GCI must provide a means for verifying the authentic identity of users, service providers, and information.**
- ➔ **The GCI must minimize opportunities for and permit redress of fraudulent use or abuse of facilities and services.**



Interoperability and Open Standards

- ➔ The GCI must support a wide variety of user equipment through a limited number of standard or widely accepted interfaces, protocols, and objects.
- ➔ National and international standards must be used, where appropriate, to promote interoperability, wide equipment availability, and low costs.
- ➔ The GCI must seamlessly link multiple public and private networks.

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GCI



Provide High-Quality, High-Capability Services

- ➔ The GCI must provide the availability and performance needed to support a wide range of present and future applications and services.
- ➔ The GCI must enable applications and services that combine audio, video, still image, and other data formats.
- ➔ The GCI must provide high-dependability, high-integrity performance.
- ➔ The GCI must provide for user portability and mobility.
- ➔ The GCI must be scalable.
- ➔ The GCI must support a wide variety of billing and payment options.
- ➔ The GCI must evolve from current information infrastructure resources.

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GCI



Provide an Information Marketplace

- ➔ **The GCI must let users know what services, information, and capabilities are available at any time.**
- ➔ **The GCI must provide easy entry for new providers and users.**
- ➔ **The GCI must promote the integration of existing applications to create new products and services.**
- ➔ **The GCI must include mechanisms to ensure orderly and effective reprovisioning of services during transition periods.**

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**Thank You
for
your attention**

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